

WHAT IS CLAIMED IS:

1. A method for measuring body temperature while regulating the temperature of at least a portion of a patient using a heat exchange catheter inserted into a lumen of the patient's body, the heat exchange catheter having conduits that 5 enable circulation of a heat exchange medium between a heat exchange portion of the catheter and a heating/cooling apparatus for adding or removing thermal energy from the heat exchange fluid, the heating/cooling apparatus controlled by a controller, comprising:

10 providing a temperature probe to measure the temperature of the patient, the temperature probe providing a signal representative of the temperature of the patient to the controller;

15 circulating fluid under control of the controller between the heat transfer catheter and the heating/cooling apparatus so as to regulate the temperature of patient;

20 stopping the flow of fluid through the heat transfer catheter for a selected period of time;

determining the temperature change while the fluid flow is stopped;

25 comparing the temperature change while the fluid flow is stopped to a target temperature; and

20 controlling the heating/cooling apparatus in accordance with the comparison to controllably add or remove thermal energy from the heat exchange fluid to heat or cool the patient's blood such that the patient's body temperature is substantially the same as the target temperature.

2. The method of claim 1, wherein the temperature probe is inserted near 25 the heat transfer catheter in the patient.

3. The method of claim 1, wherein interrupting circulating fluid between the heat exchange unit and the heat transfer catheter is controlled by stopping a fluid pump within the master control unit.

4. The method of claim 1, wherein interrupting circulating fluid between 5 the heat exchange unit and heat transfer catheter is controlled by diverting the circulating fluid into a diversion pathway, stopping fluid flow from the heat exchange unit to the heat transfer catheter.

5. The method of claim 4, wherein a diverter unit having a diverter valve 10 diverts the circulating fluid into the diversion pathway, periodically stopping the fluid circulation within the heat transfer catheter.

6. The method of claim 4, wherein the master controller is controlled by a microprocessor responsive to a plurality of patient sensors supplying patient data to the processor to control the heater/cooler unit and the diverter valve.

7. The method of claim 1, wherein the temperature probe provides 15 responsive patient data to the processor.

8. The method of claim 1, wherein the master controller processor compares signals from at least two of the plurality of sensors and either adds heat or adds cooling or stops fluid flow within the heat exchange unit.

9. The method of claim 1, wherein interrupting the fluid flow between 20 the heat transfer catheter and the heat exchange unit allows the temperature measurements to level off in the heating/cooling region near the temperature probe and the heat transfer catheter, providing an accurate core body temperature measurement.

10. A method for measuring body temperature while regulating the 25 temperature of at least a portion of a patient, comprising:

providing a temperature probe having sensors to measure the temperature of patient;

providing a disposable heat transfer catheter and heat exchange unit coupled via conduits and a diverter unit that enable controlled circulation of a heat 30 exchange medium therebetween;

providing a master control unit housing a microprocessor and a heater/cooler unit within;

installing the heat exchange unit into the master control unit and into thermal communication with the heater/cooler unit;

5 inserting the heat transfer catheter into the patient;

circulating fluid between the heat transfer catheter and heat exchange unit in the master control unit, therein transferring heat between the heat exchange unit and the heater/cooler unit so as to regulate the temperature of the patient via the heat transfer catheter;

10 periodically interrupting fluid flow from between the heat transfer catheter and the heat exchange unit, diverting the circulating fluid flow between the heat exchange unit and heater/cooler unit, bypassing the heat transfer catheter;

monitoring the temperature of patient after a period time to determine an accurate core body temperature measurement; and

15 re-starting the fluid circulation between the heat transfer catheter and the heat exchange unit.

11. The method of claim 10, wherein the temperature probe is inserted near the heat transfer catheter in the patient and provides responsive patient data to the microprocessor.

20 12. The method of claim 10, wherein the diverter unit comprises a diverter valve that interrupts fluid flow between the heat transfer catheter and the heat exchange unit when the valve is activated.

25 13. The method of claim 12, wherein activation of the diverter valve rotates a vane from a flow through orientation to a diversion orientation, sealing the heat transfer catheter inflow/outflow lines.

14. The method of claim 12, wherein the controller activates the diverter valve according to predetermined time.

15. The method of claim 12, wherein the controller activates the diverter valve periodically until the temperature sensor reads the same temperature for determined period of time.

16. The method of claim 12, wherein the controller activates the diverter 5 valve based on the previously determined rate of temperature change.

17. The method of claim 10, wherein the temperature probe accurately measures the temperature within the heat exchange region after the temperature achieves equilibrium.

18. The method of claim 10, wherein the measured core body temperature 10 is used to generate a predictive heating/cooling curve, based on the controller programming.

19. The method of claim 10, wherein the diverter unit is a flow actuated valve installed in the heat exchange fluid flow stream between the heat transfer catheter and the heat exchange unit to control the fluid circulation path.

15 20. The method of claim 19, wherein the periodic fluid flow interruption stops fluid circulation when a rotating member of the flow actuated valve rotates into a short circuit orientation, stopping fluid circulation to the heat transfer catheter.

21. The method of claim 19, wherein the periodic fluid flow interruption 20 stops flow for a predetermined time, until an electrical contact mounted on the rotating member engages an electrical contact pad, thereby sending the sensed temperature signal to the controller.

22. A heat transfer catheter system, comprising:
25 a heat transfer catheter insertable into a patient;
a disposable heat exchange unit having a fluid pathway therewithin and incorporating an integral pump head adapted to move fluid through the fluid pathway;

30 conduits coupled to the heat transfer catheter and heat exchange unit that enable circulation of a heat exchange medium therebetween upon operation of the pump head;

a diverter unit that periodically redirects the fluid pathway, bypassing the heat transfer catheter; and

5 a reusable master control unit having a heater/cooler and a pump driver, the disposable heat exchange unit being adapted to couple to the master control unit such that the pump driver engages the integral pump head and so that the fluid pathway is in thermal communication with the heater/cooler.

23. The system of claim 22, wherein the diverter unit is a diverter valve activated by the controller.

10 24. The system of claim 22, wherein the diverter unit is a flow actuated valve.

25. The system of claim 24, wherein the heat exchange unit comprises two layers, a stiff back plate and a thinner heat exchange layer bonded thereto, the pattern of bonding between the two layers defining a serpentine pathway.

15 26. The system of claim 25, wherein the master control unit defines a cavity into which the heat exchange unit couples, wherein fluid flow through the serpentine pathway causes inflation of the thinner heat exchange layer relative to the stiff back plate and subsequent compressive retention of the heat exchange unit within the cavity.

20 27. The system of claim 22, wherein heater/cooler comprises a thermoelectric heater/cooler.

28. The system of claim 22, further including a plurality of sensors supplying patient data to the master control unit, the master control unit being adapted to operate the heater/cooler based on the supplied patient data.

25 29. The controller of claim 28 wherein the master control unit comprises a microprocessor responsive to each of the sensors to control the heater/cooler, wherein the microprocessor is configured to compare the signals from at least two of the plurality of sensors and produce an alarm condition when the signals do not agree.

30. The controller of claim 29 wherein the microprocessor further receives a target temperature input and a sensor signal that represents a sensed patient temperature, the microprocessor being configured to add heat to the heat exchange medium if the target temperature is above the patient temperature and
5 remove heat from the heat exchange medium if the target temperature is below the patient temperature, periodically interrupt fluid circulation within the heat exchange unit and the heat transfer catheter, and wherein the microprocessor responds to the signal from the sensor with a proportional integrated differential (PID) response such that the rate at which patient temperature approaches the target temperature is
10 controlled.

31. A method for measuring body temperature while regulating the temperature of at least a portion of a patient using a heat exchange catheter inserted into a lumen of the patient's body, the heat exchange catheter having conduits that enable circulation of a heat exchange medium between a heat exchange portion of
15 the catheter and a heating/cooling apparatus for adding or removing thermal energy from the heat exchange fluid, the heating/cooling apparatus controlled by a controller, comprising:
measuring the temperature of the patient using a temperature probe,
the temperature probe providing a signal representative of the temperature of the
20 patient to the controller;

circulating fluid under control of the controller between the heat transfer catheter and the heating/cooling apparatus so as to regulate the temperature of patient;

25 analyzing the temperature signals received from the temperature probe for a selected period of time to determine a peak temperature;

comparing the determined peak temperature to a target temperature;
and

controlling the heating/cooling apparatus in accordance with the comparison to controllably add or remove thermal energy from the heat exchange fluid to heat or cool the patient's blood so that the determined peak temperature approaches the target temperature.

5 32. The method of claim 31, wherein analyzing the temperature signals includes:

 sampling the signals at a predetermined interval,

 determining the highest temperature value sampled within a selected range of the predetermined intervals and storing that determined value in a memory 10 of the controller,

 incrementing the selected range of predetermined intervals a selected number of times and, after each incrementing, repeating determining the highest temperature value sampled within the incremented selected range of predetermined intervals and storing that value, and

15 calculating the peak temperature value from the stored determined values.

33. The method of claim 31, wherein analyzing the temperature signals includes:

 sampling the signals at a predetermined interval,

20 determining the lowest temperature value sampled within a selected range of the predetermined intervals and storing that determined value in a memory of the controller,

 incrementing the selected range of predetermined intervals a selected number of times and, after each incrementing, repeating determining the lowest temperature value sampled within the incremented selected range of predetermined intervals and storing that value, and 25

calculating the peak temperature value from the stored determined values.

34. The method of claim 32, further comprising:
calculating an offset value; and

5 adding the offset value to the peak temperature before comparing the peak temperature to the target temperature.

35. The method of claim 34, wherein calculating the offset value includes calculating a static offset value.

10 36. The method of claim 34, wherein calculating the offset value includes calculating a dynamic offset value.

37. The method of claim 36, wherein calculating a dynamic offset value includes calculating the dynamic offset as follows:

$$\text{Offset}_{RT} = \frac{\text{Offset}_{Calc} \bullet \ln|\Delta PF_{RT}|}{\ln|\Delta PF_{Calc}|} \text{ where:}$$

Offset_{RT} =Dynamic real time offset

15 Offset_{Calc} =Offset calculated when flow stopped; calculated as:

$$\text{Offset}_{Calc} = T_{Core} - T_{Peak} \text{ where:}$$

T_{Core} = Temperature sensed after flow is stopped for a selected period and sensed temperature equilibrium is reached

T_{Peak} =Temperature sensed just before flow is stopped

20 ΔPF_{RT} =Real time temperature differential between an instantaneous peak sensed blood temperature and the corresponding instantaneous temperature measurement of the heat exchange fluid

ΔPF_{Calc} =Temperature differential between the peak blood temperature sensed just before flow stoppage and the corresponding temperature of the heat exchange fluid measured at the same time.

25 38. A system for regulating the temperature of at least a portion of a patient's body, comprising:

a heating/cooling apparatus;

a heat exchange catheter for insertion into a lumen of the patient's body, the heat exchange catheter having conduits that enable circulation of a heat exchange medium between a heat exchange portion of the catheter and the

5 heating/cooling apparatus for adding or removing thermal energy from the heat exchange medium;

a temperature sensor disposed in the lumen downstream of the heat exchange catheter for providing temperature signals representative of the temperature of body fluid flowing through the lumen; and

10 a controller responsive to the temperature signals to control the heating/cooling apparatus to add or remove thermal energy from the heat exchange medium.

39. The system of claim 38, wherein the controller includes a processor and a memory, the processor capable of being programmed by software to
15 sample the temperature signals at a predetermined interval,

determine the a selected temperature value sampled within a selected range of the predetermined intervals and store that determined value in a memory of the controller,

20 increment the selected range of predetermined intervals a selected number of times and, after each increment, repeating determining the selected temperature value sampled within the incremented selected range of predetermined intervals and store that value, and

calculate a peak temperature value from the stored determined values.

40. A system for regulating the temperature of at least a portion of a
25 patient's body, comprising:

a heating/cooling apparatus;

5 a heat exchange catheter for insertion into a lumen of the patient's body, the heat exchange catheter having conduits that enable circulation of a heat exchange medium between a heat exchange portion of the catheter and the heating/cooling apparatus for adding or removing thermal energy from the heat exchange medium;

10 a temperature sensor disposed in the lumen downstream of the heat exchange catheter for providing temperature signals representative of the temperature of body fluid flowing through the lumen, the temperature sensor configured to move within the lumen in response to the flow of body fluid within the lumen; and

15 a controller responsive to the temperature signals to control the heating/cooling apparatus to add or remove thermal energy from the heat exchange medium.

41. The system of claim 40, wherein the controller includes a processor and a memory, the processor capable of being programmed by software to sample the temperature signals at a predetermined interval,

20 increment the selected range of predetermined intervals a selected number of times and, after each increment, repeating determining the selected temperature value sampled within the incremented selected range of predetermined intervals and store that value, and

calculate a peak temperature value from the stored determined values.